individuals who have acquired the pack habit. Yet while we cannot but admire the instinct for individual action thus displayed, it must be confessed that success in modern conflicts—military or industrial—is mostly commanded by disciplined forces organised for co-operative effort against the common enemy.

At a meeting of the London Section of the Society of Chemical Industry held during November, a long discussion took place on Dr. M. O. Forster's suggestion that a chemical intelligence department should be instituted by the Government as a branch of the Board of Trade. Although the majority of speakers agreed that an organisation for chemical industry was necessary, there appeared to be a disinclination to entrust the Government with control of this department. A scheme for a co-operative organisation established by the chemical industry itself had already been advocated in September by the *Chemical Trade Journal.* This development, although a consummation devoutly to be wished, scarcely seems practicable in view of the separatist tendencies which still manifest themselves from time to time, both in the chemical profession and among chemical industrialists.

After the war much of the plant newly erected for the manufacture of high explosives will be available for the production of synthetic dyes and other fine chemicals. The relationship between these factories and the existing chemical works will need to be dealt with sympathetically and impartially by a competent authority, otherwise much loss of capital and energy will ensue as the result of competition between organisations working on similar lines. The elimination of this internal friction in our chemical industries would be a useful function of the suggested chemical intelligence department.

Many reasons have been advanced to explain our inability to develop the industries based on chemical synthesis. Taken separately, these factors are inadequate to account for the failure. Collectively they are effects of a fundamental cause discovered in early-Victorian times by Justus von Liebig, who, after a visit to these islands, declared roundly that "England ist nicht das Land des Wissenschaftes." One may well ask what chance have we of reforming in this respect? A gleam of hope arises from the following consideration. Formerly the advantages of a German university training were confined to 1851 Exhibitioners and to a few of the more well-to-do among us. To-day considerably more than a million of our fellow countrymen, drawn at an impressionable age from every station in life, are pursuing their scientific studies at an open-air German university under conditions which compel their undivided attention. Many of them realise very forcibly that the advantages possessed by their enemy instructors are due entirely to scientific organisation. When our soldier-students return to civil life will they insist upon scientific control of all national affairs? In that possibility lies our strong hope.

THE MOLECULAR VOLUMES OF LIQUIDS.

The Molecular Volumes of Liquid Chemical Compounds from the point of view of Kopp. By G. Le Bas. Pp. xii+275. (London: Longmans, Green and Co., 1915.) Price 7*s.* 6*d.* net.

TO anyone interested in the progress and development of science in this country, and in the attitude of the general community towards it, it is a significant and welcome sign that English publishers should now be found willing to undertake the issue of highly specialised works of the kind under review. For nothing would seem more clearly to indicate the spirit which is gradually coming over the community than the fact that there should be a demand, even if limited, for such a book. No doubt this demand has been stimulated by the influence of the more active and progressive teachers in our universities and leading schools of science. This series of monographs on biochemistry, physics, and inorganic and physical chemistry, comprising up to now some three dozen volumes, each the work of an eminent specialist, marks a new departure in the scientific literature of this country. The books are not text-books in the ordinary sense; that is, they are not intended to be used in or to accompany class-teaching. They are addressed mainly to those who have already passed through lecture-room courses, and who before embarking upon the work of investigation in some particular branch of experimental inquiry are desirous of making themselves acquainted with the present state of knowledge in that special department. Their publication at the present time is most opportune.

The titles of some of the volumes may not, at first sight, suggest that they have any practical bearing upon the problems with which we are more immediately confronted. But to disparage them on this account is to take a very restricted view of their utility. As they deal, for the most part, with what may be called frontier—or pioneering—work, they are of the very greatest use to those who are bent upon exploratory service. They may be compared to the maps which aid in the initial stages of an exploration; like all maps of a partially surveyed district, they may be imperfect and at times even erroneous; they indicate not only trodden paths, but suggest new routes; they serve to confirm imperfectly established facts, and lead to the correction of errors. It is almost a platitude to say that nearly every new departure in science seems at the time it is made to have no very obvious relation to the needs or conditions of our daily life. No one can possibly set a limit to the prospective usefulness of even the most recondite physical fact.

In the book before us, which has occupied nearly eight years in its preparation, Mr. Le Bas has brought together the results of the large amount of experimental work which has been spent upon the subject of the molecular volumes of liquid compounds since the time of Kopp, now upwards of seventy years ago. Kopp was not the first to attack this subject, but he was certainly the first to attempt to give a definite significance to the conception by seeking to establish the conditions under which proper quantitative values might be ascertained. Up to his time no rational method had been suggested whereby these values could be determined under presumably comparable conditions—say, at their normal melting- or boiling-points. Objections, of course, may be urged against the employment of either the melting point or the boiling point as a valid condition of comparison, but in Kopp's time no other course was open to him, and there can be no question that it did serve to bring out regularities and relationships which otherwise would have been wholly obscured. Kopp's example in this respect has been followed by almost every subsequent worker in this special field. It is with the large mass of material which has thus been accumulated that Mr. Le Bas's book mainly deals, and it is for the reason that the work is fundamentally based upon the principles laid down by Kopp that the particular form of its title is due.

Of course, Kopp and his immediate followers suffered under the disability that present-day conceptions of chemical constitution were wholly unknown to them, and possibly even wholly undreamt of. These ideas are mainly due to a development of the chemistry of carbon compounds long subsequent to Kopp's day. Although Kopp made determinations of unimpeachable experimental accuracy on a number of organic compounds, his interpretation of the results they afforded was limited, and, indeed, occasionally erroneous, owing to his lack of knowledge of the effect of constitutive influences. He compared things between which we now know no real analogy exists, and made generalised deductions from wholly irrelevant and inconsistent data. The work of his successors was more or less guided by the light of contemporary theory, but, of course, even in their case it only reflects the state of knowledge or speculation at the particular period it was undertaken.

Now the great merit of Mr. Le Bas's monograph is that it not only collects and groups in a systematic arrangement the results of all the work hitherto published on the molecular volumes of liquid chemical compounds, but it discusses and seeks to interpret these results with the aid of all that is known or surmised concerning the constitution of such compounds, however it may have been ascertained. In this manner Mr. Le Bas has been able to give a great expansion and at the same time a greater precision to the conception of the intimate relation which indubitably exists between such a physical property as molecular volume and chemical constitution. Thus he shows, for example, that no physical property is apparently so well adapted to elucidate the ring structure of a compound as its molecular volume, and he expresses the hope that this will henceforward take its legitimate place among other physical properties as an instrument of research. That the determination of this value is readily possible, and with a degree of accuracy amply sufficient for its purpose as an indicative factor, had already been shown by the author. He finds that the values at the boiling point may be calculated with approximate accuracy by the following simple formula:—

$$\frac{d_0}{d_t} = 1 + c\left(1 - \frac{273}{\mathrm{B.P}}\right)$$

the only data necessary being the density at 0° and the boiling point. The mean value of the constant c, as deduced from a considerable number of inorganic liquids investigated by the present writer, is 0·463. An almost identical value of c is obtained for organic cyclic compounds without side-chains. By means of the above formula the molecular volumes of liquid compounds may be calculated with an error of less than 1 per cent. In open-chain compounds the value of c increases by 0·024 for every addition of CH_2.

The book concludes with a suggestive summary of the theory of molecular volumes, in which the author discusses the present position of the additive principle, its value, and its limitations. He clearly shows, what, as he observes, had already been pointed out by the present writer, that there is a periodic relation in the atomic values of the various elements, and he illustrates this by a diagram, with special reference to the non-metallic elements. He summarises the discussion in the main body of the work concerning the variations in the volumes of the atoms, more particularly in the cases of oxygen, sulphur, nitrogen, and chlorine. He traces the effect of constitutive influences, *e.g.*, the influence of the homologous increment, unsaturation, and ring structure; valency, and groups; and lastly he discusses the special conception embodied in molecular volume and its relation to other physical properties, such as boiling point, surface tension, and viscosity.

The book is by no means easy reading, but it bears on every page the evidence of thoughtful, critical insight, and may be unreservedly commended as a faithful and accurate digest of the state of present knowledge upon what is confessedly a complicated and intricate subject.

T. E. THORPE.

THE PARTITIONS OF NUMBERS.

Combinatory Analysis. By Major Percy A. MacMahon. Vol. i., pp. 300. (Cambridge: At the University Press.) Price 15*s.* net.

THOSE who, like the present writer, have been privileged to hear Major MacMahon give an account of his methods of solving the problems of which the well-known Latin Square is typical—problems of interest to many who are not professed mathematicians—have been waiting for this treatise with eagerness. Volume i. has now appeared, and it amply fulfils the expectations which have been formed. If we may quote from the preface, the object of the work is to present to mathematicians an account of theorems in combinatory analysis which are of a perfectly general character, and to show their connection as parts of a general doctrine. The modesty of the author forbids him to mention that the greater part of the work is his own, as well as most of the important theorems which are treated. It is fair to say that Major MacMahon has developed a new line of mathematical work, and that many of the main theorems, rescued here for the first time from the author's papers in scientific periodicals, must form an essential part of text-books on higher algebra in the future.

The author enters a justifiable protest against the relegation of combinatory analysis to a part of the theory of numbers, for the theory is algebraical up to the point of determining the enumerating generating functions. He traces his method back to Laplace, who used these functions for the theory of probability, but he has greatly simplified Laplace's method by the extended use of symmetric functions.

The work is divided into six sections, each subdivided into a series of chapters. As a detail of arrangement, it would surely have been more convenient for a reader to find the chapters numbered consecutively throughout, instead of beginning again with each section. Section i. contains the theory of symmetric functions, and of distributions into parcels and groups in general, and it is especially notable in its clear account of the uses of Hammond's operators. The theory of separations is taken up in section ii., where an important generalisation of Girard's well-known formula is obtained. Permutations are taken up in section iii., where is proved what the author has ventured to call the "master theorem." This theorem really deserves such a title in a subject of this nature, and this section is, in fact, one of the most interesting in the book. The applications of the theorem to such problems as the sum of the nth powers of binomial coefficients are very elegant, and the chapter on lattice permutations is a very valuable piece of work. The theory of the compositions of numbers appears in section iv., and further applications of the master theorem are developed in this connection. Simon Newcomb's celebrated problem suggested by a game of "patience" is treated in a very attractive manner. Section v. takes up the question of distributions on a chess board, preceded by a discussion of the perfect partitions of numbers. This section will completely displace any other account of such problems, and shows the power of the analytical method very strongly. The sixth and last section is concerned with the enumeration of the partitions of multipartite numbers.

These brief references will serve to indicate the main outlines of the work, but they necessarily miss many of its characteristic features. The book is interesting even when the analysis becomes somewhat cumbrous, which the author allows it to do as little as possible. It is published by the Cambridge University Press, and maintains the tradition of excellence of this series. While congratulating the author, we hope that the second volume will not be long delayed.

THE TINTOMETER.

Light and Colour Theories and their Relation to Light and Colour Standardisation. By J. W. Lovibond. Pp. xii+90. (London: E. and F. N. Spon, Ltd., 1915.) Price 6*s.* net.

MR. J. LOVIBOND is known as the inventor of the tintometer. He has written no preface to the present book in the ordinary acceptation of the word, but commences with a chapter on "Purpose," which is largely devoted to enumerating the awards he has received from international juries and various scientific socie-